

Polar Stratospheric Cloud Characteristics Observed with Airborne Lidar During the SOLVE Campaign

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Long-range flights of the NASA DC-8 were made across the Arctic vortex during the SOLVE (SAGE III Ozone Loss and Validation Experiment) campaign conducted in three deployments to Kiruna, Sweden from 29 November 1999 to 16 March 2000. The NASA Langley airborne UV DIAL (Differential Absorption Lidar) was flown on the DC-8 to obtain vertical profiles of ozone and multiple-wavelength aerosol backscatter characteristics to an altitude of 28 km along the flight track. Aerosol backscatter ratios were measured simultaneously at 1064 (IR), 622 (VIS), and 311 nm (UV), aerosol depolarization was measured at 1064 and 622 nm, and ozone was measured using DIAL wavelengths of 301.6 and 310.9 nm. Temperature profiles were obtained with a separate Rayleigh and Raman lidar system operating with a fundamental laser wavelength of 355 nm and with a multi-angle microwave radiometer system.

Throughout the SOLVE campaign, polar stratospheric clouds (PSC's) were observed at cold temperatures below 195K inside the polar vortex, starting with the first local flight from Kiruna on 5 December. Evidence was also observed of the swelling of sulfate aerosols as the temperatures approached that of NAT (nitric acid trihydrate) PSC's. During the first SOLVE deployment (5-16 December), all of the PSC's were observed in the 17.5-23 km (geometric) altitude range, and they had properties of Type Ia NAT PSC's, which included low to moderate IR and VIS scattering ratios, significant IR and VIS depolarization, and low wavelength dependence of backscattering. These properties reflect a low density of large, frozen NAT aerosols. The physical properties and geographic location of many of these PSC's imply a possible wave influence in their formation. During the second SOLVE deployment (14-29 January), the temperatures were colder in the vortex, and PSC's were observed from below 14 km, which were mainly wave-driven Type II PSC's, to the highest PSC's with tops near 25 km. PSC's in the 16-25 km range were ubiquitous in the cold regions of the vortex, and depending on the ambient temperatures, they generally had properties of either Type Ia or Ib PSC's with distinct domains for these different populations. However, there were some transition regions that did not fall cleanly into one of these categories. During the first half of the third deployment (27 February-9 March), Type Ia PSC's were found to be confined to below 18 km in the coldest region of the vortex, and this was in the presence of equally cold temperatures extending up to 22 km. No Type Ib or Type II PSC's were observed. The reason that the NAT formation was limited to this lower altitude region is thought to be due to denitrification of the region above 18 km by earlier PSC activity. Inside the vortex there was also a background aerosol layer extending from 18 km down to below 14 km, and it is in this same region that the PSC's formed when the temperatures were low enough. Ozone measurements across the vortex also provided a direct indication of vortex dynamics and conditions related to background aerosol distributions and PSC formation.